CLIC WORKSHOP
CLIC MAGNET WORKSHOP SUMMARY

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SLAC
October 15, 2009

CLIC MAGNET WORKSHOP PARTICIPANTS

CERN:
Lucie Linssen, Andrea Gaddi, Benoit Cure,, Stefano Sgobba, Alexey Dudarev, Hubert Gerwig, Dieter Schlatter, Herman Ten Kate (slides)

ETHZ: Alain Herve

INFN Genoa: Pasquale Fabricattore, Stefania Farinon

IOWA STATE UNIVERSITY: John Hauptman

KEK (Web Ex): Akira Yamamoto, Kenichi Tanaka, Yasuhiro Makida

SLAC: Wes Craddock

UPSULLA UNIVERSITY: Roger Ruber

GENERAL TOPICS

- COORDINATION OF EFFORT AND EXCHANGE OF IDEAS AND RESOURCES
- SPECIFIC DETECTOR SUPERCONDUCTING SOLENOIDS
- GENERAL SOLENOID ENGINEERING, CONSTRUCTION AND DETECTOR INTEGRATION ISSUES
- ADVANCED HIGH PURITY ALUMINUM STABILIZER METALLURGY

Solenoid Design and Engineering
(Herman Ten Kate Introduction Slide)

New team

Recently a new team for design and engineering of the next generation linear collider detector magnets was formed at CERN/PH

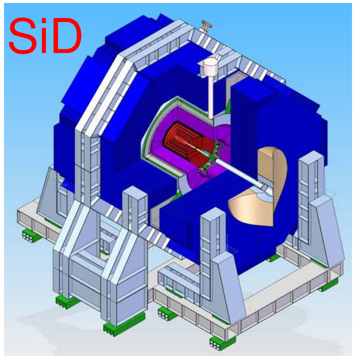
Mission

- predesign and engineering of the CLIC Detector Magnet system
- provide support to the ILC detector magnet developments
- initiate and participate in common R&D on conductor, coil structures and magnet service systems and infrastructure
- establish and maintain a worldwide collaboration
- organize yearly workshops (1st at CLIC Oct 09, 2nd at MT21 Oct 09)

Short term goals

- bring the world engineers for detector magnets together
- seek common issues and start the R&D
- write the magnet system chapter in the CLIC Conceptual Design Report

Solenoid R&D
(Herman Ten Kate Introduction Slide)



CLIC Solenoid

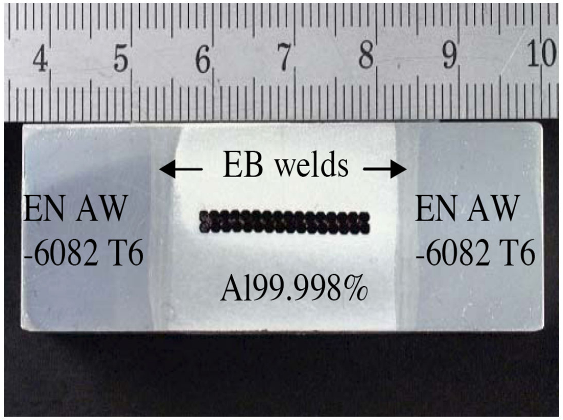
- 5 T in free bore of 6 m and 6 m length (possibly up to 8)
  6T peak magnetic field, leading to marginal temperature margin of ~1 K and elevated stress levels of ~200 MPa
- layout presently similar to SiD but 1m larger bore!

R&D issues identified, driven by cost and reliability of operation

1) reinforcement of superconductor following 2 routes
   - doping of Al to raise yielding stress in ATLAS/CMS type of Al/NbTi coextruded conductor
   - use of cable-in-conduit type of conductors (new in detector magnets)
2) increase of temperature margin and stability by improved conduction in windings, sub-cooling or, again, use of cable-in-conduit conductor
3) Minimize coil thickness by using high yield strength materials
4) Weight of system and handling: use of ~14 kt iron yoke or an inner and outer solenoid (~1.5 kt) in combination with extra shielding

Challenges in High Field Solenoids - Alain Herve
Summary and Key Points

- Provided an overview summary of the design philosophy and challenges of the CMS solenoid
- Key points of CMS solenoid design:
- State of the art 2.6 GJ @ 12 kj/kg
- Reinforced conductor design



- 1.8 K temperature margin, 130 K peak temp if dump breaker fails
- 6 Layers for 5 T instead of 4 layers for 4 T with strain < 0.15%
- Reinforced conductor still a good solution for 5 T
- 40 strands in superconducting cable limit from cabling machines
- The alternative choice is high strength (yield ~ 210 MPa) aluminum stabilizer as in the Al-0.1%Ni ATLAS conductor

SiD Solenoid Status and Review – Wes Craddock
Summary and Key Points

- Preliminary design for LOI completed
- Design and construction techniques based on the CMS solenoid
- Same 12 kJ/kg but 60% stored energy and ½ the length of CMS
- Designed for push pull; On board electrical; Liquefier connected with flex line
- Much work remains: 3D field calculations, mechanical design and structural analysis, assembly and integration with SiD, cryogenic integration with 1.8 K QD0 and integration with an internal dipole/antidipole SC magnet.
- Working on advanced conductor designs; Internal cable reinforcement and extrusion options. Dilute alloys with Ce, Y, TiB_2,, Sc, and carbon nanotubes.

Preliminary Analysis Towards a 5 T Solenoid – Benoit Cure
Summary and Key Points

- Preliminary design of a CLIC detector solenoid with SC temperature margin studies
- Design and construction techniques based on the CMS solenoid
- Same 12 kJ/kg with CMS stored energy but ½ the length of CMS
- Yoke options being studied in parallel.
- Looking at 5 layer and 6 layer options with larger than CMS cond.
- Further Studies: Detailed magnetic field analysis, heat loads, cooling schemes, quench protection, stability analysis, and material properties.

Twin Solenoid Study – Alexey Dudarev
Summary and Key Points

- Presented the Twin Coaxial Solenoid Option for CLIC eliminating an iron flux return.

- Preliminary Parameterization Study of the two solenoids inlcuding magnetic fields and forces on the solenoids.

- **CONCLUSIONS OF STUDY:**
- Stresses on solenoid is the most import means of selection
- A 1 meter radial spacing is not possible
- 1.5 m spacing with 8 to 8.5 m outer solenoid length is possible
- 2 m spacing with 8 to 9 m outer solenoid length is possible
- More basic studies, engineering and detector issues would be required to pursue this concept.

- Also presented some of work of Evgeni Diakov on hybrid nanostructured Al + Al-Li alloy + C_{60} conductor development.

Design Study of 5 T Superconducting Solenoids for LC Detectors and High Intensity Muon Beam

Ken-ichi Tanaka, Yasuhiro Makida, Akira Yamamoto

- Presented a magnetic field analysis of the SiD solenoid and a magnet comparison to CMS
- Presented alternative conductor configurations for SiD
- Compared the SiD solenoid to the Pion capture solenoid for the muon beam at J-Parc.
- They conclude: A 5 T solenoid using the CMS / ATLAS conductor hybrid concept is feasible for an SiD scale magnet

Options for Yield Strength Enhancement of Al Stabilized Superconductor – Stefano Sgobba
Summary and Key Points

- Reviewed the CMS conductor mechanical and electrical properties
- Reviewed the CMS conductor manufacturing process
- Concludes: The CMS 6082-T51 alloy for the conductor and the 5083-H321 alloy for the winding mandrel are acceptable for a 5 T solenoid.
- Provided details of the Al-0.15%Ni stabilizer and the effect of cold work by roll forming on the insert.
- Information on 3 other hybrid conductor designs
- Alternatives to the Al-0.15%Ni stabilizer such as dispersion strengthened or aluminum composites would need significant work before they could be used in a 5T solenoid.

Coil Winding Issues – Pasquale Fabricatore
Summary and Key Points

- Layed out the engineering design and analysis in winding large size conductors.
- Presented thermal stability of and winding aspects of cable in conduit conductor.
- In the lab, aluminum stabilized conductors are difficult to quench, CIC conductors are easy to quench.
- Many details of the CMS conductor winding and transportation
- A 6 layer winding should be O.K. but would need verification.
- Conductors > 75 mm tall (CMS 64 mm) would pose great difficulty and require substantial engineering and testing.
- Coil dimensions > 7.2 meter pose serious transportation problems.

Yoke Options at a CLIC Detector and Outlook – Hubert Gerwig
Summary and Key Points

- For the best combination of vibrational stability and shielding one should strive for short detector, long tunnel and massive shielding.
- Reduce lever arms supporting QD0 and extend the tunnel as a solid foundation.
- Presented the ILD QD0 ANSYS vibration analysis of Hiroshi Yamaoka.
- Copper coils on an end cap can reduce its mass by 50% while only effecting field uniformity by 5%.
- A superconducting anti-solenoid could reduce the field on QD0.

Infrastructure and Push Pull Options – Andrea Gaddi
Summary and Key Points

- Presented the Push Pull Option for CLIC
- **Conclusions for easiest component integration and operations:**

1) Liquefier should reside on the cavern wall connected to the magnets with flexible LHe transfer lines.

2) The heavy power supply and associated breakers are also best left off of the detector in a service cavern.

3) The dump resistor is best left on the detector if possible.

4) A flexible HTS bus bar connecting the power supply to the solenoid would be highly desirable. CERN is developing semi-flexible MgB2 cable for LHC.

5) Stray magnet fields require very careful consideration becoming quit dangerous above 200 G.

6) Cable chains will be used to permit permanent connections between on detector and off detector components while assuring smooth detector movement.

CONCLUSIONS AND ACTION ITEMS

- **CLIC Solenoid Design is just beginning using validated ILC solenoid designs as a starting point for CLIC**
- **The CMS and ATLAS solenoid engineering, construction techniques and conductor metallurgy provide the starting point and basis for all ILC superconducting magnet designs. This saves an enormous amount of engineering time and cost.**
- **Magnet design ideas were shared**
- **CERN, KEK, SLAC and other institutions will work together on advanced conductor metallurgy**
- **A central web site will collect all available resources that can be shared among Linear Collider design groups (e.g. high purity aluminum, superconducting cable, R&D tools and facilities)**
- **An informal workshop for conductor metallurgy at MT21, next week.**
- **THIS WAS A VERY GOOD START IN COORDINATING THE INTERNATIONAL LINEAR COLLIDER MAGNET DESIGN EFFORT.**